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ANALYSIS OF METHODOLOGICAL APPROACHES TO THE CONSTRUCTION OF DYNAMIC SYSTEMS OF INVESTMENT IN INFORMATION DEVELOPMENT

The object of research is theoretical and methodological approaches to mathematical modelling of dynamic nonlinear systems to ensure dynamic management of the investment process of information development of enterprises. Methodological aspects of building dynamic investment systems, maximizing the effectiveness of system interaction in information development are considered. One of the most problematic places is the formulation of the optimal approach to the methods of system analysis of decision management.

The paper provides an opportunity to solve a wide range of problems, related to the flexible management of investment projects in the implementation of information technology. The study used the economic component of the formation of information resources, which contains an integral investment component of the information system. This is due to the fact that the proposed discreteness of this approach in the complex dynamics of the value of the information system contains partial estimates. Therefore, there should be a scheme of constant review of its value, which contains a dynamic component of the investment value of the information system with properties.

The axiomatic approach was used in one of the most common approaches in the formal study of systems. The peculiarity is that the model is based on certain basic assumptions that do not require theoretical justification – on axioms. The study identified the main characteristics of the dynamic investment component of the system.

Investments will have the properties of assessing information flows as part of information development. In particular, the research used approaches to modelling many solutions of the investment resources management process. The stages of modelling the process of dynamics and state of the system, implementation of the information support system are determined. This provides an opportunity to identify and assess the stages of investment, analysis of key risks and existing opportunities, defining strategies and methods of response, system typing. As well as the development and implementation of action plans to minimize the variability of investment areas and information structure.

Keywords: *information system, dynamic regulation, dynamic investment, resource cost, investment management.*

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1. Introduction

A common characteristic of the formation of systems theory is the investigation of possible aspects of the study of real decision-making in the midst of heterogeneous systems.

The first group of objects has systems that do not contain integrity.

The basic understanding is a system that has a clear definition of the general concept, depending on the sources of formation. This type of system is derived from the natural type of the origin, in which the basic element is taken as its components, the properties and relationships of these elements are highlighted. The properties of the elements thus shape the nature of a system as interconnected elements.

Connections (flows) are the exchange of information between the elements of a system and its connection with the external environment, important from the point of view of the system. One of the most important in complex flow systems is the information that accompanies all other flows and is predominant.

In view of this, it is advisable to look at complex systems through the development of ideas about systems analysis.

Characterizing the development of methods of systems analysis, it concerns the development of general systems theory in the system and decision management.

2. The object of research and its technological audit

The object of research is theoretical and methodological approaches to mathematical modeling of dynamic nonlinear systems to ensure dynamic management of the investment process of information development of enterprises.

The management process should not be considered as a separate stage, but as a general systemic approach to the investment process.

Characteristic problem areas of the study of these aspects of modeling a complex investment process in the implementation of providing information systems is its stochastic nonlinearity.

3. The aim and objectives of research

The aim of the work is to study the approaches and determine the stages of modeling the management of dynamic investment systems to ensure information development.

To achieve the goal of the study, the following scientific objectives were identified:

1. To analyze modern approaches to the formation of investment process models.
2. To identify the mathematical apparatus of the class of equations to describe complex systems for the formation of continuously supporting development of information systems in the management of the dynamic investment process.

4. Research of existing solution to the problem

Given the study of systems and the basics of their construction, it is necessary to analyze the stages of development of modeling and the concept of systems. The main areas of solving this problem include the formation of the concept of system as a specific area of scientific approach, which formed the concept of analytical systems, as well as developed the concept of management.

The following works pay attention to partial solutions of efficiency, management, which should take into account all internal and external factors, affecting the object of management, and works [1, 2] are devoted to the main difficulty of its implementation, related to the complexity of human behavior. In these works, the author has advanced in understanding and awareness of the system of human collectives, groups, understanding the complexity of human management.

In turn, the work on the issues of systematic approaches, provide a solution to the partial timing of the investment process in the specific framework of a project [3]. However, the issues of effective control of system factors remain unresolved. That, in turn, effective management must take into account all internal and external factors, affecting the object of management, and the main difficulty of its implementation is related to the complexity of human behavior. In this regard, the author of [4] has advanced in understanding and comprehending the system of human collectives, groups, understanding the complexity of human management.

The next stage in the categories of development of systems science can be noted insufficient disclosure of the functional aspects of adaptation and conservatism.

In [5] and, in particular, classical works made a contribution to the study of systemicity as a self-sufficient subject. The safety of a system is ensured by the use of the external environment, due to which the system increases the number of internal connections, increases its complexity, while increasing the efficiency of its operation. Incomplete in this direction is the development of the idea of systemicity.

In turn, aspects of the concept of systematization are fully formed in the study [6]. This study of cybernetics characterizes the relationship between natural and machine systems, develops ideas about system typing, the principle of optimality in management, the development of simulation in technical systems.

According to [7], the systems approach is considered as a generalizing concept that combines the interests of various sciences, such as cybernetics, information theory, solutions, factor analysis, network theory and more.

These ideas coincide with the main directions of application of general systems theory, but do not include the ability to assess the complexity and level of a system [8].

In turn, the development of system theory and philosophy of systems give us the opportunity to form a view of the integrity of the investment process as a system, rather than as individual elements of the process [9], which generally emphasizes the incompleteness of the view.

In turn, the authors of [10] identify isomorphism, which in the study of the dynamics of investment processes can provide the necessary apparatus for understanding different classes of processes, phenomena and their interdisciplinary relationships.

Thus, the results of the analysis of the development of systematic methods allow us to conclude that the general view of investment dynamics in terms of systems theory and the systemic nature of investment provide an opportunity to form and select the apparatus of methods and approaches. As well as an analysis of the objective reality of its interpretation from different points of view. In order to avoid personal distortion of the prospects of the investment process and its dynamics of development and to eliminate the subjective interpretation of future expectations.

5. Methods of research

In the course of the research the aspects of the methodology of modeling the system approach are considered, in particular, the characteristics of the construction of dynamic systems in terms of investment processes.

In general, the characteristics of the types of dynamic systems are shown in Fig. 1.

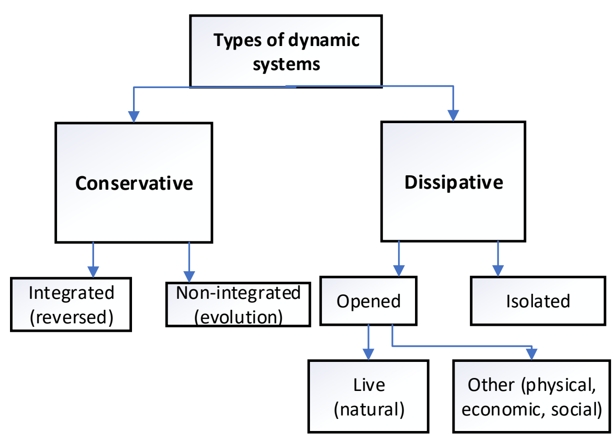

Fig. 1. Types of dynamic systems [5]

Characterizing a dynamic system as an object, we can distinguish for them the property of the concept of state at a certain point in time. This system will have a set of parameters that will change over time.

For such equations it is possible to set the equation of development of the description of the system of values of the state u_1, u_2, ... , u_n at some point in time $t=t_0$, the general form of which:

$$\frac{du_i}{dt} = \dot{u} = f_i\left(u_1, u_2, ..., u_n, t\right), \quad (1)$$

$$\frac{du_i}{dt} + D_i \Delta u_i = f_i\left(u_1, u_2, ..., u_n, t\right). \quad (2)$$

Let us investigate the description of conservative type systems. They are described by the equations of dynamic motion (Newton's law) of linear nature and are determined by the states of a system at each time point of the observation area, represented by the formula of a general form:

$$F = m\ddot{x}, \quad (3)$$

where m – object mass; $\ddot{x}$ – motion acceleration.

It is also possible to consider systems with their subsequent holistic analysis. In this case, the dynamic model is based on a number of principles, which are represented by the general formula:

$$\mathrm{H} = T + V = \mathrm{const}, \quad (4)$$

where T – time, during which the motion took place; V – speed of the object.

The potential to change the value is given by the minimum vectors of virtual changes in the system of its position, which is represented by the formula of a general form:

$$F_i = -\frac{\partial V}{\partial x_i} = 0 \Rightarrow \frac{dV}{dt} = 0,$$
$$F_S = 0 \Rightarrow F_S \delta r_S \Rightarrow \sum_s F_S \delta \rightleftarrows r_S = 0 \Rightarrow \delta W = 0, s = 1, ..., n, \quad (5)$$

where V – speed of the object; r_S – displacement value; W – vector of displacement force; s – set of points of possible displacements; t – period of time, during which the motion took place.

D'Alembert's principle is described as systems with a dynamic component, in which virtual displacements of points with superimposed connections are necessary, so that the work of all forces on any displacements is zero. The turnover of the system is complete.

To characterize the observation of a dynamic system, it is necessary to adequately choose the coordinate system, which simplifies the formation of the motion of the internal connections of the system. There is the D'Alembert-Lagrange principle for this. As well as the Hamilton principle, which is characterized by the smallest value of the transition of system state configurations for a given time interval – the principle of least action, represented by the formula of a general form:

$$\dot{x}_i = \frac{\partial H\left(p, x\right)}{\partial p_i}, \qquad \dot{p}_i = \frac{\partial H\left(p, x\right)}{\partial x_i}, \quad (6)$$

where p – vector of generalized coordinates; x – coordinate of the displacement vector.

When integrating a system into a solution of optimality, it is necessary to find the derivative of the first integral of the solution. Characterizing the states of dissipative level systems, the states of such systems change completely over time. Isolated systems under conditions of dissipation in the process of evolutionary direction of motion come to equilibrium. Nonlinear systems have their own characteristics:

– there is no inherent superposition;
– is described by nonlinear differential equations;
– have many «equivalent» solutions;
– properties and parameters of a system depend on the current state of the system elements.

Representation of a complex system is shown in Fig. 2.

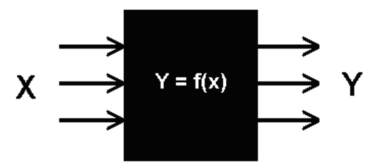

Fig. 2. «Black box». Control parameters. Order parameters

Distinguishing the characteristics of dynamic investment process management systems, the elements will have the properties of complex systems with internal solutions, which will depend on many external relationships with constant changes in the state of the investment system itself.

6. Research results

As a result of the study, describing a dynamic investment complex system, investments will have the properties of assessing information flows as part of information development.

We will characterize the modeling of the analysis system.

The indirectness of cognition is characterized by the ways, in which complex dynamic systems are modeled, that is the selected object is replaced by another object with similar properties, but the study of which is more economical.

The functions of system models are:

– description of reality;
– description of causal relationships, components of a system;
– imitation of system behavior;
– simulation experiment;
– use of management and optimization tasks.

The study of the object of the investment process system, as well as the new information system of the management organization, can be represented by a set of models.

Systems analysis uses a modeling apparatus to solve problems of object research, new system design and management organization. The properties of the system are mainly reflected by a set of models.

In the process of forming an investment model it is necessary to reflect the target aspect of the properties:

1. Pragmatism – to form the requirements for achieving the desired state of the investment process, finding optimal solutions for the dynamics of management.

2. Ensure completeness of coverage, break it down into separate complex blocks, providing simplification, and set the approximate accuracy of the investment dynamics process.

3. Set the finiteness of individual investment horizons of the dynamics of the investment process, thereby setting the criteria for the development of the information system.

Given the multilevel process and the complexity of system evaluation, the complexity of implementation while maintaining the simplicity of the system, it will be necessary to characterize the adequacy of the approximate model.

Adequacy is the main characteristic of the constructed model. A model is adequate to an object if the simulation results are used to predict the behavior of a real object.

In the process of modeling related stages, the result is certain systems of knowledge or their formal reflection.

A formal description of the stages of modeling a dynamic system of the investment process will be as follows:

The first stage is to maximize the homeomorphism of objects, to compare each element of investment and information element with one element and the relationship of efficiency over time. Give the opportunity to solve the problem of microinvestment in the middle of one homogeneous process.

The second stage is the system of ideas about the model of the object of communication dynamics of the information system.

The third stage – a dynamic system of investment must be endowed with the characteristics of the isomorphism of the investment process with a mirror image of each individual investment, its opposite in the direction of the element of development and payback.

As a result, many investment models with a large amount of iteration are formed between the dynamic elements of the system.

The methodological classification of application of models in dynamic systems of investment in information development is carried out.

Classification features of models:
- system research;
- properties of areas of change of parameters and variables;
- description of uncertainty;
- taking into account inertia;
- method of setting the relationship between parameters and variables;
- target;
- form of representation of system properties.

The most acceptable is the use of models of internal construction of the system, in terms of the model of structures.

From the observation and study of the model of fuzzy structures, as mentioned above, these models can change the intrinsic characteristics of the system, while the system will have the properties, acquired in interaction with the external environment characteristics. Models of this type are described by a nonlinear characteristic of the «black box» type («input-output»).

Input-output models reflect the basic properties of the system, isolation and communication with the external environment, as well as the impossibility of complete identification of all properties.

Before describing the structures of the financial and economic model, it is necessary to show the fundamental possibility of such modeling. In other words, it is necessary to answer the question of whether it is possible to model many financial flows in the information support system (ICS). To show this possibility, we will use some rules of the system approach.

We can assume the following that the goal system has a hierarchical structure, which should be represented as the most general model of the type: «input» – «state» – «output» – «management» – «supersystem» (Fig. 3).

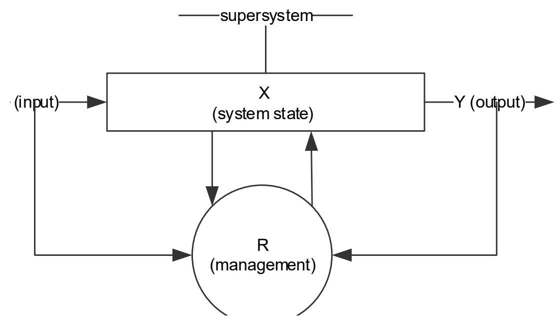

Fig. 3. General model of a complex system [5]

In *static models* in the implementation of the investment process there are no transitions between the phases of investment. That is, the system responds instantly to any disturbance within the overall phase of the investment process. The set of investment curves of one complex system will be a description of an algebraic equation. Also, a static model can display dynamics, but only at a certain point in time. That is, this nature of the description can reflect a complex system sequence of descriptions of static models of changes in system states over time. This will require the use of recurrent relations in the form of difference equations:

$$a_{n+1}=F(a_n,a_{n-1},...,a_{n-k+1}), \quad (7)$$

where F – function; k – argument; a – element of the system in a state of time; n – period of the system state.

Equation (7) allows you to calculate the next members of the projected numerical sequence through the values of the previous members. The recurrent relation uniquely determines the sequence a_n if k is the first member of the sequence. The recursive relation is an example of recursive sequence determination.

Dynamic models will take into account the factors of the curves of the information process, as well as the inertia of the system in the interaction of investment processes. Such models are described by integer order differential equations with a time variable.

Linear integer order differential equations are equations, in which the internal differential operator is included linearly:

$$L_n\left[\varphi(x)\right]-\gamma\int_a^b K(x,y)Pm\left[\varphi(y)\right]dy=f(x). \quad (8)$$

In characterizing dynamic investment processes in information development as a continuous environment, the possibilities of using integer order differential equations to obtain optimal control of systems with distributed parameters have been investigated. This will make it possible to determine the optimal characteristics of a dynamic system of investing in information development in a continuous closed form.

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7. SWOT analysis of research results

Strengths. The strengths of this study can be considered the view of modeling dynamic investment processes through the prism of complex nonlinear systems that do not have their own superposition and are closed to the environment. A comparison of the approach of dynamic interaction modeling with the description of the method of estimating the function of system models is given. Thus, the proposed methods make it possible to build an effective dynamic system of investing in information development. This, in the end, makes it possible to obtain a comparative description of the management of the investment process of information development of an enterprise.

Weaknesses. The analysis of the system modeling process showed that one of the key groups with high dynamism and heterogeneity is the factor of nonlinearity of the system, associated with the implementation of investments. Thus, as to the complexity of modeling, the most acceptable is the use of models of internal construction of the system, in terms of the model of structures. From the observation and study of the model of fuzzy structures that can change their own characteristics, the systems will have the properties of the acquired features of the new system, in interaction with the external environment.

Opportunities. In the future, the development of dynamic investment management systems acquires the possibility of using adaptive algorithms to ensure information development and the use of nonlinear Fredholm equations, in which the internal differential operator is nonlinear. This will provide an opportunity to solve a wide range of problems, related to the flexible management of investment projects in the implementation of information technology.

Threats. The negative consequences include the unpredictable occurrence of multiple influences of different directions of information systems development on the investment management system, the relationship of the system with environmental factors, which in complex closed systems will give many uncontrolled results. This, in turn, may reduce the possibility of pre-identification of such dependencies.

8. Conclusions

1. The analysis of the current state of the methodology of mathematical modeling of complex systems of evolutionary characteristics of systemicity has been carried out. Based on this, the characteristics of the dynamics systems in the management of investment processes of information development have been given. The result is the separation of the implemented modeling of closed system management, and giving it the properties of dynamic adaptation.

2. The stages of modeling the process of managing the investment dynamics of the implementation of information support modeling methodology, which reduces investment costs for information development of production at each stage of the investment process, have been determined.

The development of systemic methods allows us to conclude that the general view of investment dynamics from the theory of systems and systemic nature of investment provides an opportunity for form and select the apparatus of methods and approaches, analysis of the objective reality of its interpretation from different points of view.

For solving the description of the class of equations of complex systems for the formation of a continuously support information system in the management of the dynamic investment process, the first class of equations based on the Lagrange multiplier method with the following condition of obtaining the conditions of optimality and the possibility of applying integer order differential equations is proposed.

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